

Lumbar spinal stenosis – surgical outcome and the odds of revision-surgery: Is it all due to the surgeon?

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Abstract.

BACKGROUND: Surgical decompression is the intervention of choice for lumbar spinal stenosis (LSS) when non-operative treatment has failed. Apart from acute complications such as hematoma and infections, same-level recurrent lumbar stenosis and adjacent-segment disease (ASD) are factors that can occur after index lumbar spine surgery.

OBJECTIVE: The aim of this retrospective case series was to evaluate the outcome of surgery and the odds of necessary revisions.

METHODS: Patients who had undergone either decompressive lumbar laminotomy or laminotomy and spinal fusion due to lumbar spinal stenosis (LSS) between 2000 and 2011 were included in this analysis. Demographic, perioperative and radiographic data were collected. Clinical outcome was evaluated using numeric rating scale (NRS), the symptom subscale of the adapted version of the German Spinal Stenosis Measure (SSM) and patient-reported ability to walk.

RESULTS: Within the LSS-cohort of 438 patients, 338 patients underwent decompression surgery only, while instrumentation in addition to decompression was performed in 100 cases (22.3%). 38 patients had prior spinal operations (decompression, disc herniation, fusion) either at our hospital or elsewhere. Thirty-five intraoperative complications were documented with dural tear with CSF leak being the most common (33/35; 94.3%). Postoperative complications were defined as complications that needed surgery and differentiated between immediate postoperative complications (≤ 3 weeks post operation) and complications that needed revision surgery at a later date. Within all patients 51 revisions were classified as immediate complications of the index operation with infections, neurological deficits and hematoma being the most common. Within this group only 22 patients had fusion surgery in the first place, while 29 were treated by decompression. Revision surgery was indicated by 53 patients at a later date. While 4 patients decided against surgery, 49 revision surgeries were planned. 28 were performed at the same level, 10 at the same level plus an adjacent level, and 10 were executed at index level with indications of adjacent level spinal stenosis,

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adjacent level spinal stenosis plus instability and stand-alone instability. Pre-operative VAS score and ability to walk improved significantly in all patients.

CONCLUSIONS: While looking for predictors of revision surgery due to re-stenosis, instability or same/adjacent segment disease none of these were found. Within our cohort no significant differences concerning demographic, peri-operative and radiographic data of patients with or without revision were noted. Patients, who needed revision surgery were older but slightly healthier while more likely to be male and smoking. Surprisingly, significant differences were noted regarding the distribution of intraoperative and early postoperative complications among the 6 main surgeons while these weren't obvious within the initial index group of late revisions.

Keywords: Lumbar spinal stenosis, claudication, treatment options, laminotomy, fusion, revision

1. Introduction

Neurogenic claudication (NC) due to symptomatic lumbar spinal stenosis (LSS) is a painful condition causing significant functional disability. While the cause of LSS is multifactorial, thickened ligamentum flavum (LF) accounts for up to 85% of spinal canal narrowing [1]. Any factor leading to additional narrowing of the spinal canal, such as axial loading and disc bulging, translational instability under loading conditions and functional hyperlordosis will typically worsen clinical symptoms [2]. At the same time, these dynamic phenomena are often not accurately reflected in supine cross-sectional imaging [3]. Current management options for LSS include medications, physical therapy, epidural injections, alternative medicine, and surgery. While surgical techniques already vary to a large extent [4–7], unfortunately, no clear consensus has been reached to determine which patients are most likely to benefit from a concomitant lumbar fusion. On the one hand patient satisfaction following lumbar decompression alone ranges from 59 to 96% [8], on the other hand reoperation rates of up to 25% within the first 5 years are reported. The relief of leg symptoms by surgical decompression for lumbar stenosis is well supported by the literature, while the effect on back pain is more controversial. Some studies support the theory that back pain relief should not be an expected outcome of decompression and that substantial back pain may be a contraindication to decompression only [9]. Therefore, stabilization may be recommended for patients with substantial preoperative back pain even in the absence of well-accepted indications for stabilization such as spondylolisthesis, severe deformity, or sagittal malalignment [10]. Asking patients about their expectations of surgical outcome after decompression surgery the most common answers are pain relief and improved ability to walk [11,12]. While perioperative complications such as CSF leaks or hematoma and infections might be related to surgical performance surgical failures have different components. Early surgical failures might result from insufficient decompression and preoperative lumbar instability [4,13] with late recurrence of back or leg problems due to acquired spinal instability or adjacent level degeneration [4,13–20]. Mostly, revision surgery is required at the index or at adjacent levels. The rates for reoperation after decompression without fusion for LSS are rather consistently reported to be around 8–10% 2 to 4 years following surgery [21,22]. Kim et al. reported a reoperation rate of 5.88% in a case series of 983 patients after decompression and fusion [23]. The metaanalysis by Goel et al. with 29000 patients reviewed fenestration surgeries and showed an average reoperation rate of $7.58\% \pm 5.29\%$ in 8.28 ± 6.26 years follow up as compared to laminectomy alone ($12.70\% \pm 7.49\%$, 6.50 ± 2.12 years follow up). Laminectomy with or without fusion showed a reoperation rate of $11.22\% \pm 4.25\%$ in 6.00 ± 2.60 years follow up period. The comparative results of these studies were however not significant [24].

While recent studies were able to identify particular factors, such as obesity, smoking, or fusion as decisive for the outcome of lumbar operations, the literature has not demonstrated yet whether these factors influence reoperation [17,25,26].

The goal of this study was to evaluate whether factors can be evaluated to predict revision surgery.

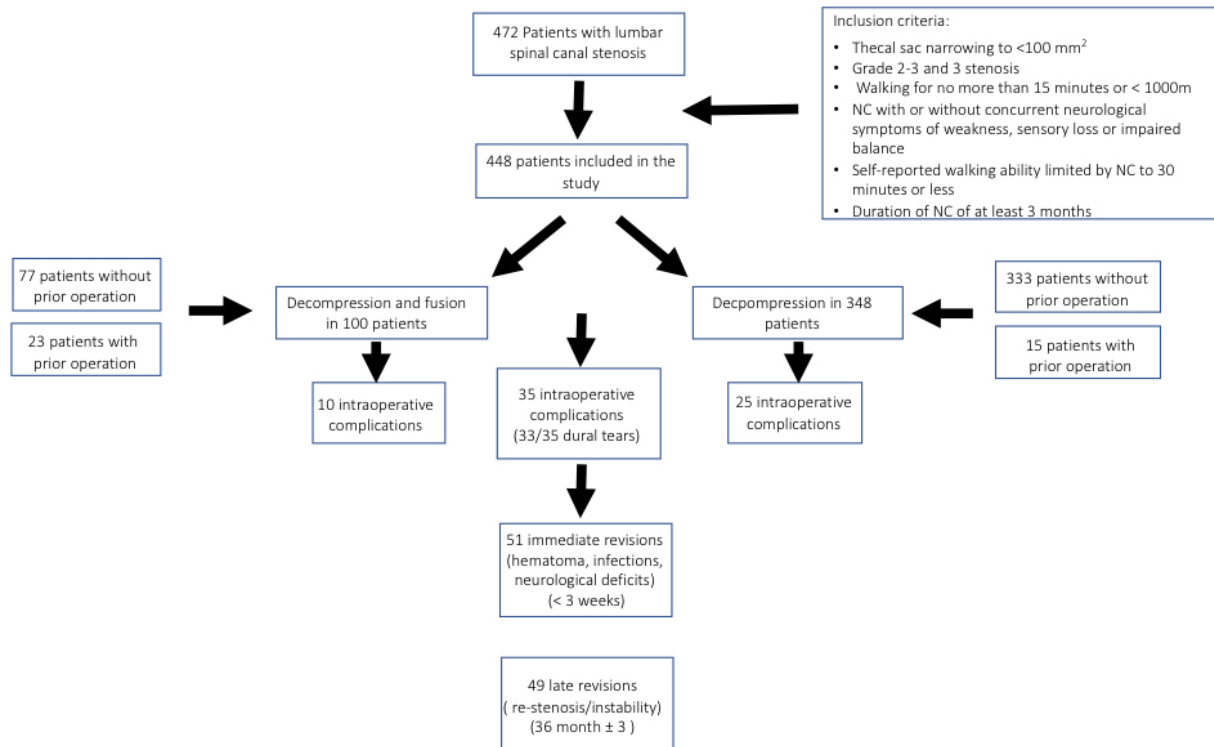


Fig. 1. Inclusion criteria.

2. Methods

2.1. Patient population

Between January 1, 2000 and December 31, 2011, 472 consecutive patients at our institution underwent spinal surgery due to symptomatic spinal canal stenosis and failure of conservative care. These patients form the basis for this retrospective study on prospectively collected data. Data extraction began after institutional approval for this study was obtained. As for demographic data, sex, age, BMI, comorbidities, smoking and history of osteoporosis were recorded. Operative and anesthesia reports as well as hospital charts were reviewed to add data on number and levels of surgery, fusion or decompression, main surgeon as well as complications, pre- and postoperative NRS (numeral rating scale), the symptom subscale of the adapted German SSM, claudication and self-reported ability to walk (in m). Patients who were able to walk for more than 30 minutes without any symptoms, who had critical stenosis of the aorta or disabling osteoarthritis in the knee or hip joint were excluded. In the end 448 patients were included in the study (Fig. 1).

2.2. Radiological evaluation

Most patients underwent MR imaging of the lumbar spine prior to indication to estimate the extent of spinal stenosis. However, we also saw patients, that were unable to undergo MRI because of claustrophobia, cardiac pacemakers, neuro-modulators or where the initial MR imaging procedure in a horizontal

position did not reveal the full extent of compression. Therefore, in these cases we performed lumbar myelography which was completed by a postmyelography CT scan. Additionally, plain anteroposterior and lateral radiographs of the lumbar spine and in some cases CT scans were obtained prior to surgery to exclude congenital disorders. The degree of stenosis was defined as Grade 1 for 1/3 reduction of canal area, Grade 2 for 1/3 to 2/3 reduction of canal area, and Grade 3 for greater than 2/3 reduction of canal area [27].

2.3. Indications for surgery

An indication for surgery was made in adult patients with radiologically confirmed spinal canal narrowing and neurogenic claudication. Included were patients with 1) thecal sac narrowing to less than 75 mm² [28] or grade 2–3 and 3 stenosis; 2) walking for no more than 15 minutes or less than 1000 m induced NC with or without concurrent neurological symptoms of weakness, sensory loss or impaired balance; 3) self-reported walking ability limited by NC to 30 minutes or less; 4) duration of NC of at least 3 months. All 4 criteria had to be met for a patient to be included in the study.

Either decompressive lumbar laminotomy or laminotomy and spinal fusion was performed. The decision for decompression only or decompression with fusion was made after thorough evaluation of patient's symptoms (dominant back- vs. leg-pain), imaging (degenerative disease) and discussion with the patient.

3. Results

3.1. Patient demographics

Four hundred forty-eight consecutive patients, two hundred-seventeen males and two hundred thirty-one females, with lumbar spinal stenosis (LSS) who had undergone decompression surgery or decompression and spinal fusion were included in our study. 38 patients had prior spinal operations without fusion (decompression, disc herniation) either at our hospital or elsewhere. The median age at surgery was 69.9 years (range 34–89 years), while more women were operated on.

Regarding comorbidities hypertension, heart disease (heart failure, coronary heart disease) and diabetes were the most frequent followed by hypothyroidism and neurological diseases (Table 1). Almost every patient (418/438; 95%) presented with at least one comorbidity and there was a mean of 2 comorbidities per patient (range 0–8). A history of cigarette smoking was present in 12.6% of patients.

3.2. Surgical details

Within the cohort, three hundred forty-eight patients (77.5%) received decompression only, while fusion in addition to decompression was performed in 100 cases (22.5%) (Fig. 2).

A significant difference was seen in the distribution of decompression/fusion in between the patients with primary operation as 80% (333) received decompression only with just 39% [15] of patients in the group that had prior operation. Chi² equals 32.587 with 1 degree of freedom. The two-tailed P value is less than 0.0001.

1-, 2-, 3-, 4- and 5-level surgeries were performed in 274 patients (61.0%), 130 (29.0%), 38 (8.5%), 5 (1.1%) and 2 (0.4%), respectively with a total of 686 levels treated. The most common level of surgery was L4–5 (33.0%) followed by L3–4 (16.0%), L3–5 (14.7%) and L4–S1 (6.3%) (Fig. 3).

Table 1
Comorbidities

Comorbidity	Decompression (n=384)	Fusion (n=100)	Re-Operation due to new condition (n=46)	All Patients	Decompression	Fusion	Re-Operation due to new condition
<i>Cardiac conditions</i>							
Controlled Hypertension	194	39	16	55,6%	55,7%	39,0%	34,8%
History of Myocardial infarction	21	4	2	6,0%	6,0%	4,0%	4,3%
Coronary heart disease	73	11	10	21,0%	21,0%	11,0%	21,7%
Atrial fibrillation	13	6	2	4,7%	3,7%	6,0%	4,3%
PAOD	16	3	1	4,5%	4,6%	3,0%	2,2%
<i>Pulmonary conditions</i>							
Asthma	9	2	3	3,1%	2,6%	2,0%	6,5%
COPD	17	3	3	5,1%	4,9%	3,0%	6,5%
History of pulmonary embolism	4	2		1,3%	1,1%	2,0%	0,0%
<i>Gastrointestinal conditions</i>							
Diabetes	63	17	5	19,0%	18,1%	17,0%	10,9%
Ulkus ventriculi, Diverticulitis	12	4	1	3,8%	3,4%	4,0%	2,2%
Obesity (BMI > 30)	30	12	2	9,8%	8,6%	12,0%	4,3%
<i>Endocrinologic conditions</i>							
Hypothyreosis	42	11	5	12,9%	12,1%	11,0%	10,9%
TVT	6	3	1	2,2%	1,7%	3,0%	2,2%
Renal failure	23	4	1	6,3%	6,6%	4,0%	2,2%
Rheumatic disease	22	10	1	7,4%	6,3%	10,0%	2,2%
<i>Orthopedic conditions</i>							
Hip replacement	15	4	4	5,1%	4,3%	4,0%	8,7%
Knee replacement	11	1	5	3,8%	3,2%	1,0%	10,9%
<i>Neurological conditions</i>							
Parkinson's disease, MS, Epilepsy	36	10	4	11,2%	10,3%	10,0%	8,7%
Depression	12	2	3	3,8%	3,4%	2,0%	6,5%
Cancer	21	7	1	6,5%	6,0%	7,0%	2,2%
Other	33	7	3	9,2%	9,0%	7,0%	6,5%

Distribution Decompression/Fusion

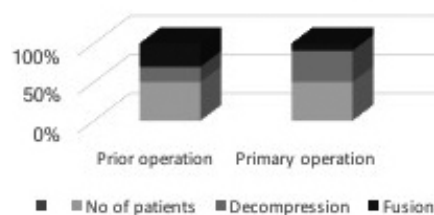


Fig. 2. Distribution decompression/fusion.

The median estimated blood loss for 1-, 2-, and 3-level decompression surgeries was 50, 100, and 200 ml, respectively with highest blood loss of 2 l in a 4-level and 2.5 l in the 5 level revision surgery with fusion. In the 2 cases of severe bleeding, one operation had to be suspended.

Eighty-seven percent (383/438) of the operations were performed by 6 surgeons, who were the leading spine surgeons of the Orthopedic Department over the last 10 years (range 28–134 procedures) with the remaining 13 percent (63/448) distributed between 3 more experienced (more than 15 procedures) and 5

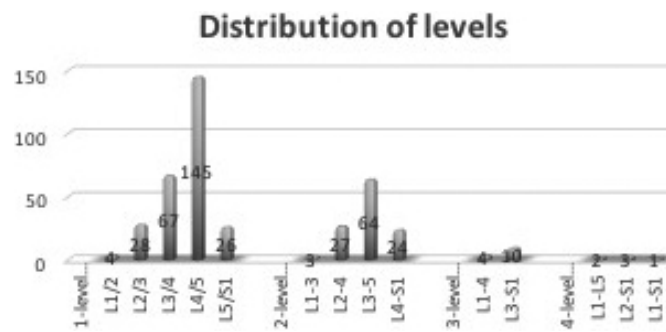


Fig. 3. Distribution of treated levels.

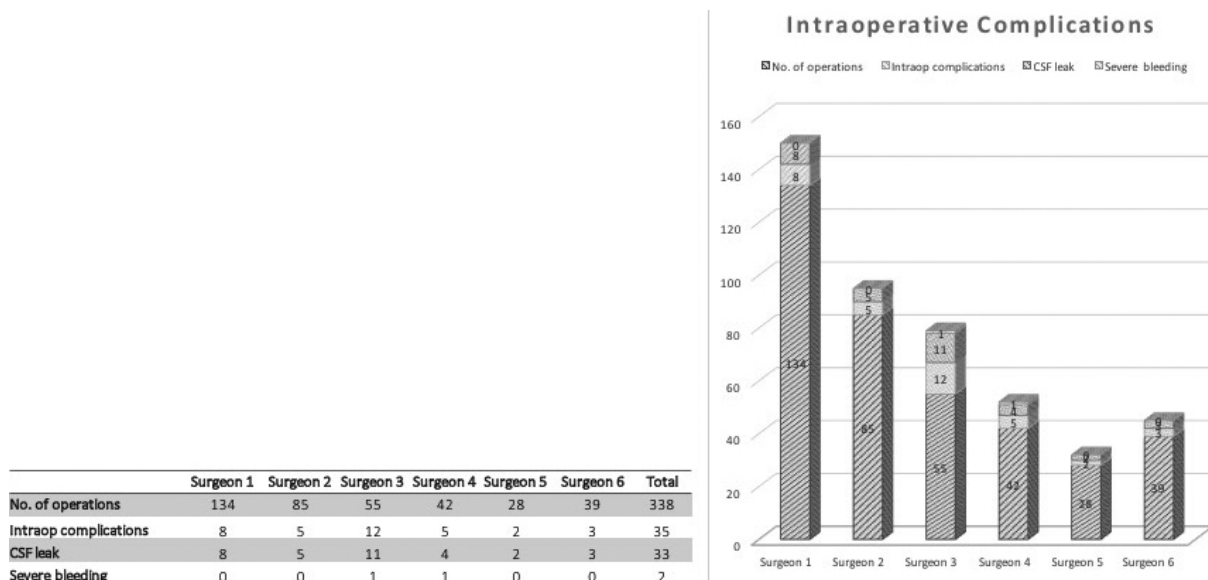


Fig. 4. Relation of intraoperative complications to main-surgeon.

less experienced (< 10 procedures) surgeons, while teaching operations were accounted for the leading surgeon.

Thirty-five intraoperative complications were documented with dural tear with CSF leak being the most common (33/35; 94,3%). These were far more common during decompression surgery than fusion (11/24). All dural tears were repaired intraoperatively. 4 patients needed further surgery due to complications of the dural tear, such as persistent csf leak or imminent infection.

A significant difference was seen in the distribution of intraoperative complications within the group of main-surgeons with 2 surgeons having significantly more complications. Chi² equals 3.764 with 1 degree of freedom. The two-tailed *P* value is less than 0.05 (Fig. 4).

Postoperative complications were defined as complications that needed further surgery and differentiated between immediate postoperative complications (\leq 3 weeks post operation) and conditions that needed revisions surgery at a later date.

Within all patients 45 revisions (10,0%) were classified as immediate complications of the index operation with infections, neurological deficits and hematoma being the most common. Within this group

Surgeon	Surgeon 1	Surgeon 2	Surgeon 3	Surgeon 4	Surgeon 5	Surgeon 6	Total
No. of operations	134	85	55	42	28	39	338
Postop complications	18	10	12	7	2	2	51
Infections	4	3	2	2	1		12
Hematoma	5	3	2	1		1	12
Neurological deficit	6	2	4	3	1		14
Screw malpositioning	0	1	2	2			5
Segmental collaps	1	1	1				3
Other	2		1			1	4

Fig. 5. Immediate postop complications.

only 17 patients had fusion surgery in the first place, while 28 were treated by decompression only (Fig. 5).

Here again, we found a significant difference between surgeons.

Revision surgery at a later date was indicated by 53 patients due adjacent level spinal stenosis, adjacent level spinal stenosis plus instability and stand-alone instability (11.8%). While 4 patients decided against surgery, 49 revision surgeries were planned. 28 were performed at the same level, 10 at the same level plus an adjacent level, and 10 were executed at index level with indications of. Therefore, the incidence of reoperation at the index level is 6.4%, while adjacent level reoperation accounted for 2.2%. Interestingly risk of re-operation seemed to be higher in male patients, but no other risk-factors were seen within our study.

The median time to revision was 36 month \pm 3 with 63% of the patients [31] were fused within the surgery, while in 37% [18] re-decompression was performed.

No significant differences ($p < 0,05$) were found by Chi²-Test between surgeons regarding re-operation numbers and percentages.

3.3. Clinical outcome

The mean preoperative backpain according NRS was 6/10 \pm 2/10 (range 1/10–10/10), which decreased significantly to a mean of 3/10 (range 1/10–7/10) postoperatively. Self-reported and documented walking distance increased from a mean of 457 \pm 499 m to unrestricted in most of the patients. Furthermore, claudication resolved in 98% of the patients with just seven out of 438 complaining of leg symptoms postoperatively. Very similar results were seen when looking into the symptom subscale of the SSM.

3.4. Evaluation of revision cases

All revision operations due to new conditions were evaluated by plain radiographs and/or flexion/extension films in addition to MRIs to assess potential instability caused by previous decompression. In the 8 patients diagnosed with recurrent index level spinal stenosis/adjacent level spinal stenosis plus instability the radiographs showed mild spondylolisthesis (grade I) without any signs of excessive facetectomy. None of the patients with preoperative spondylolisthesis demonstrated any increased slippage.

4. Discussion

Spinal stenosis with and without associated degenerative spondylolisthesis is a common problem, and treatment choices vary from multiple non-operative modalities to surgical interventions of variable extent. With fusion techniques becoming more and more common for spinal stenosis within the last couple of years, various studies tried to evaluate reasoning in treatment choices [8,21,29–34]. These studies demonstrated benefit from surgical intervention initially but a steady decline with time and re-operation rates varying between 5 and 23% [22,35–38]. Simultaneously repeated surgery for the treatment of lumbar stenosis is associated, on the average, with lower effectiveness and greater complications as compared with initial surgery [39,40]. This is supported by our study as patients with prior operations and patients with revision surgeries were more likely to need fusion. The presence of degenerative spondylolisthesis has often been considered to be a sign of instability, although definition of that term is still in dispute. Some studies have suggested that there may be a risk of iatrogenic slip or an increased degree of spondylolisthesis after decompression surgery in patients with degenerative spondylolisthesis or even without due to compromising segmental spinal stability by the very nature of the surgical approach, with the likelihood of excessive motion augmented when wider decompressions are performed, greater ligamentous disruption occurs, or multiple levels are included [4,41,42]. Indeed, postlamino- or laminectomy instability is one of the most common indications for reoperation following decompression as it was in our study. Minimally invasive surgery (MIS) techniques support, among other advantages, are supposed to preserve the posterior osseoligamentous structures, and may therefore minimize destabilization while achieving adequate decompression of the neural elements [16,43–47]. In our cohort only 3 patients in the revision group developed mild progressive spondylolisthesis within 2 to 4 years after the index surgery, which is a lot lesser than described in many other studies [41].

Within the group of intraoperative complications we saw a significant difference in the incidence of incidental durotomy within the main surgeon group. With occurrence of dural tears in 7.3% (33/448) of all procedures, we did not see more CSF leaks than other groups, but a more heterogenous distribution [43,48, 49]. While the literature reports up to 10% of incidental durotomies during decompression surgery, many multi-center studies report homogenous rates associated with age, BMI, previous surgery at the same spinal level, minimally/less invasive surgery and laminectomy [50]. Even though studies documented that durotomy did not have negative effect on long-term outcome and quality of life in patients undergoing first-time decompression surgery without fusion [51] association with a significant increase in the patient's length of stay, and risk for re-intervention for the treatment of persisting CSF leakage is reported. Even more, evidence suggests a possible inferior outcome in terms of low back pain improvement [49]. Hence the elaborateness of the surgeon needs to be discussed in cases of inhomogenous occurrence as in our cohort.

In contrast to Aono et al. [52], we saw more immediate complications due to infections and hematoma leading to neurological deficits within the decompression group, so one has to discuss that due to the small incisions hemostasis might be more challenging. The use of post-operative drains and the type of post-operative dressing is still at the discretion of the treating surgeon with no available clinical guidelines. While Glennie et al. showed in their systematic review in 2015 that the use of a post-operative drain did not influence healing rates and had no effect secondarily on infection (odds ratio [OR] 1.33; 95% confidence interval [CI] 0.76–2.30), they were not able to establish whether surgical drains prevent hematomas causing neurologic compromise [53]. These heterogenous findings are supported by the existing literature [54–56]. Postoperative surgical complications, medical conditions and unplanned reoperations have shown to be associated with higher rates of unplanned readmission, large financial burdens and less beneficial outcome being most common in decompression procedures [57].

The overall revision rate to address recurrent symptoms at the index level or adjacent segments is reported between 10–25% [58–60]. These results correspond with our findings. In contrast to Martin [22], who observed a higher risk of reoperation in younger patients, females and patients with any comorbidities, the only specific patient demographic risk factor associated with reoperation in our study seemed to be male gender and smoking. This is at least partly supported by Sato, who identified body mass index and disc height as independent risk factors for same segmental disease and male gender and facet degeneration as independent risk factors for adjacent segment disease [61].

Even though in our patient population history revealed at least one comorbidity in almost every patient (418/438; 95%) with a mean of 2 comorbidities per patient (range 0–8), incidence was even lower in the re-operation group. This is even more surprising as the patients were on average 3 years older than the patients in the non-revision groups.

As surprising as these findings are, they are in part supported by similar outcomes in the corresponding SPORT trial subgroup [17], who postulated that “lumbar fusion or particular patient characteristics, such as obesity, would render patients with lumbar stenosis more susceptible to reoperation at the index or adjacent levels” concluded that “The prevalence of other clinical factors suspected to affect outcome, such as obesity, smoking, or older age, was not significantly different between reoperation and non-reoperation groups”.

Even though reported successful clinical outcomes and functional improvement rates after revision spine surgery vary widely [26,62–64], our findings are mirrored in the literature. Concurrent with our study, Schlegel et al. evaluated patients who had undergone decompression alone or decompression plus extension of fusion for symptomatic ASD and observed a significant improvement in VAS scores in 70% of patients who had undergone extension of their fusion construct after decompression [65]. The same applies for Adogwa’s study showing that revision lumbar decompression and extension of fusion provides improvement in LBP, disability, and quality of life and should be considered a viable treatment option for elderly patients with persistent or recurrent back and radicular pain [64]. In a meta-analysis, Chang et al. reported a similar overall effect odds ratio (OR) (95% CI) of major complications, number of reoperations, and clinically excellent and good rates between the two groups (0.70 (0.60, 0.81), 1.04 (0.90, 1.19) and 0.31 (0.06, 1.59) ($z = 4.63, 0.53$ and 1.40 , respectively; $P < 0.00001, 0.60$ and 0.16 , respectively)) showing no difference in the effectiveness between the two surgical techniques [66]. This is supported by the observational non-inferior study by Austevoll et al. Even though they weren’t able to conclude that decompression alone is as good as decompression with additional fusion but postulated that due to the small differences in the groups’ effect sizes a considerable number of patients can be treated with decompression alone [67]. This is supported by Goel, who concluded that statistical data do not indicate the superiority of any particular type of surgery, which reduces the rate of reoperation [24].

5. Conclusion

In conclusion one has to state that the odds of revision surgery due to intraoperative complications might depend predominantly on the surgeons elaborateness, while re-operation rates due to re-stenosis, adjacent level stenosis or degenerative disease after surgery can’t be predicted by evaluating patients demographics, but seem to be enhanced by male gender, facet disease and deformity.

The limitations of this study are well recognized. It is a retrospective review with all the commensurate confounding factors and biases. Although preoperative and perioperative variables were recorded into a registry at the time of surgery, these variables were assessed post hoc at the time of the study’s initiation. Furthermore, no data on health-related quality of life instruments like SF-36 and Euroqol (EQ5D)

measures can be provided, which are now prospectively collected. Still, as in other studies the main postoperative goals of patients were assessed with VAS/NRS and ability to walk. Lastly, within the observed period (10 years), techniques in managing lumbar spinal canal stenosis have changed, which might be reflected in re-operation rates of procedures performed by surgeons during the early 2000s.

Conflict of interest

None to report.

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